Studies on Postoperative Pulmonary Complications after Surgery for Esophageal Cancer : Especially the Relationship between the Vagus Nerve and the Pulmonary Complication Part 1: Clinical Observation

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Studies on Postoperative Pulmonary Complications after Surgery for Esophageal Cancer: Especially the Relationship between the Vagus Nerve and the Pulmonary Complication

Part 1 : Clinical Observation

by

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Introduction

Recently, there has been an increasing number of surgical cases of esophageal cancer. However, the postoperative complications are the main obstacle to the success of this operation as compared with those of other digestive organs. Complications of the lung occur frequently following the operation for cancer of the upper two-thirds of the thoracic esophagus.

In such cases the prognosis is poor. We have carried out some investigations on the patients with esophageal cancer who had undergone radical surgery. The managements of these cases included careful explanation to the patient and his family prior to operation, frequent positive pressure breathing and suction of the secretion in the trachea, careful operative manipulations of the surrounding area around bifurcation of the trachea and the upper mediastinal region during the operation; avoidance of overhydration, performance of tracheostomy and respirator treatment for 24 to 48 hours, and then admission into the oxygen tent with a flow rate of 15 liters per minute for seven days with frequent suctions of secretion from the trachea, and frequent checkups of chest X-ray film and arterial blood gas analyses after the operation.

In spite of such managements postoperative pulmonary complications occurred in some cases.

We investigated the occurrence of these pulmonary complications following esophageal operations.

Materials and methods

From June 1970 to Aug. 1976 we treated 233 patients with esophageal diseases. Of

Key words : Esophageal cancer, Postoperative pulmonary complications, Pulmonary edema, Vagus nerve, Hypoxemia.
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these, 182 patients suffered from malignant diseases and 51 patients from benign diseases. One hundred and seventy-one out of the 233 patients (73.4%) suffered from esophageal cancer, 157 of the patients had undergone operation for esophageal cancer and 135 out of the 157 (86%) had undergone resection of the esophagus (Table 1).

The patients who had undergone resection of esophageal cancer consisted of 99 males and 36 females. Only 4 patients (3.0%) were younger than 40 years old, 56 patients in the sixties, 21 patients in the seventies, and one patient in the

Table 1. Total number of esophageal diseases

Malignant diseases·····	182
Carcinoma	171
Sarcoma	2
Readmission	9
Benign diseases·····	51
Varices	24
Hiatal hernia	5
Ulcer	3
Rupture	1
Achalasia	6
Leiomyoma	2
Diverticulum	2
Others	8

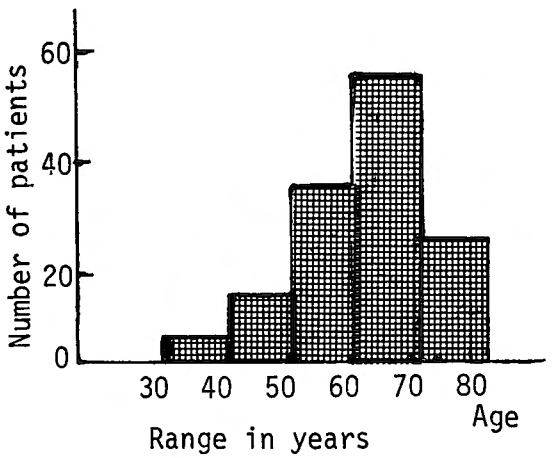

Table 2. Age distribution of resected cases of esophageal cancer

Age \ Location of lesion	Ce.Ph		Iu		Im		Ei		CE		Total	
	M	F	M	F	M	F	M	F	M	F	M	F
~ 39	0	0	1	0	0	0	0	0	2	1	3	1
40 ~ 49	0	2	0	0	5	1	1	2	2	3	8	8
50 ~ 59	4	3	0	1	7	5	0	0	13	4	24	13
60 ~ 69	1	1	0	1	26	5	8	1	11	2	46	10
70 ~	3	2	0	1	9	0	2	0	4	1	18	4
Total	8	8	1	3	47	11	11	3	32	11	99	36

Ph: Hypopharynx, Ce: Cervical esophagus, Iu: Upper intra-thoracic esophagus,
Im: Middle intra-thoracic esophagus, Ei: Lower intra-thoracic esophagus,
CE: Esophago-cardiac region

eighties. Seventy-eight patients (57.8%) were older than 60. Twenty-eight patients died within a month after operation and 38 patients died more than one month after the operation at the hospital (Table 2).

We classified the patients in these group according to the location of the lesion, age distribution, pulmonary functions and serum total protein in the preoperative period, blood loss during the operation and duration of the operation. To clarify the cause of pulmonary complications the author divided the patients who had undergone esophageal operation into three groups: the patients who died of pulmonary complications within one month after operation belonged to group Ⅰ, the patients who died of pulmonary complications more than one month after operation belonged to group Ⅱ and the patients who did not have any complications and were discharged from the hospital belonged to group Ⅲ.

We investigated preoperative pulmonary functions, the duration of the operation and blood loss during the operation, and postoperative blood gas analysis in these three groups. Furthermore, the preoperative polmonary functions and findings during the operation such as the depth of invasion and the extent of regional lymph nodes metas tases were also investigated in cases with cancer of the upper two-thirds of the thoracic esophagus.

Result

1) Classification of the postoperative complications and causes of "the operative death" and

Table 3. Postoperative complications after surgery for esophageal cancer.

Pulmonary complications	32	38.6%	23.7%
Pulmonary edema	3		
Bronchopneumonia	20		
Atelectasis	9		
Anastomotic breakdown	27	32.5%	20.0%
Mediastinitis	5		
Pyothorax	4		
Peritonitis	4		
Dehiscence of stoma	2		
Minor leakage	12		
Pleural complications	13	15.7%	9.6%
Pneumothorax	1		
Hydro-hemothorax	10		
Pyothorax (without anastomotic breakdown)	2		
Complications of heart	3	3.6%	2.2%
Congestive heart failure	3		
Auricular fibrillation	0		
Shock (resultant oliguria)	8	9.6%	5.9%
Total	83	100%	

"the hospital death"

The postoperative complications were seen in 32 cases in the respiratory system, in 27 cases with anastomotic breakdown, and in 13 cases in the pleural cavity. Among 32 cases with pulmonary complications, bronchopneumonia occurred in 20 cases, atelectasis in 9 cases and pulmonary edema in 3 cases (Table 3).

In this report, the term "operative death" implies the death within one month after the operation, and the term "hospital death" implies the death of patients who were not discharged and died in the hospital.

Almost all of the patients of "hospital death" who had pulmonary complications died within two months after operation. Out of 135 resected cases, "operative death" was seen in 28 cases (17.8%) and "hospital death" was seen in 36 cases (22.9%) (Table 4).

Table 4. Cases of esophageal cancer (1970–1967)

Total number of inpatients	171(73.4%)
Location of lesion	
Cervical esophagus	19
Upper intra-thoracic esophagus	5
Middle intra-thoracic esophagus	75
Lower intra-thoracic esophagus	15
Esophago-cardiac region	57
Number of operations	157
Number of resections	135
(resectability rate 86.0%)	
Number of "the operative death"	28(17.8%)
Number of "the hospital death"	36(22.9%)

It may be difficult to differentiate the main cause of the death because the postoperative complications occurred frequently in company with each other. In the present paper, most important causes of death which were previously mentioned were reported as if each case had only one cause of death. As for the cause of these operative deaths, pulmonary complications occurred in 11 cases (39.3%), anastomotic breakdown in 5 cases, hypovolemic shock in 4 cases, heart failure in 3 cases, and so on. On the other hand, as for "hospital death", pulmonary complications occurred in 12 cases (33.3%), anastomotic breakdown in 7 cases, recurrence in 7 cases, debility in 5 cases, and so on (Table 5).

Table 5. Causes of the "operative death" and the "hospital death"

1.	Pulmonary complications	11 (39.3%)	1.	Pulmonary complications	12 (33.3%)
2.	Anastomotic breakdown	5 (17.9)	2.	Anastomotic breakdown	7 (19.4)
3.	Bleeding	4 (14.3)	3.	Recurrence	7 (19.4)
4.	Heart failure	3 (10.7)	4.	Debility	5 (13.9)
5.	Renal insufficiency	2 (7.1)	5.	Pleural complications	1 (2.8)
6.	Pleural complications	2 (7.1)	6.	Renal insufficiency	1 (2.8)
7.	Shock	1 (3.6)	7.	Shock	1 (2.8)
8.	Liver insufficiency	0 (0)	8.	Bleeding	1 (2.8)
9.	Others	0 (0)	9.	Toxic exanthema	1 (2.8)
			10.	Heart failure	0 (0)
			11.	Liver insufficiency	0 (0)
	Total	28 (100%)		Total	36 (100%)

2) Investigations on preoperative and operative factors and the location of lesion in the cases of "operative death".

Twenty-eight patients of the "operative death" were classified into three groups as follows: cancer lesion in the esophagocardiac region (5 cases), cancer lesion in the thoracic esophagus (18 cases) and cancer lesion in the cervical esophagus (5 cases).

Using these three groups we performed some investigations on such factors as the distribution of age, pulmonary functions, serum protein in preoperative period, the duration of the operation and blood loss during the operation. These factors did not show any statistically significant differences among 3 groups (Table 6).

Table 6. Location of the lesion in the cases of the "operative death"

		Age	Total protein	%VC	%EFV 1.0	VC/m²	FEV 1.0/m²	Duration of operation	Blood loss
A	$\bar{X}$	61.2	6.60 g/dl	91.2%	67.4%	1741.0 ml	1099.4 ml	273.0 min.	1833.4 ml
	s	12.72	1.13	24.5	3.2	455.8	271.3	35.5	1131.5
	SE	5.67	0.47	10.9	1.4	203.8	121.3	15.9	506.0
	n	5	5	5	5	5	5	5	5
B	$\bar{X}$	60.0	7.00	100.0	73.3	2125.0	1535.3	315.0	1991.8
	s	11.22	0.228	15.45	12.45	219.78	236.11	95.07	1812.58
	SE	4.02	0.102	7.74	6.22	109.89	118.05	42.52	810.63
	n	5	5	4	4	4	4	5	5
C	$\bar{X}$	62.6	6.88	92.1	70.8	1967.6	1365.4	299.4	1711.8
	s	8.05	0.480	17.05	6.81	371.19	318.19	94.97	1658.18
	SE	1.90	0.11	4.26	1.70	92.80	79.63	23.03	402.18
	n	18	17	16	16	16	16	17	17

A: Esophago-cardiac cancer, B: cancer of hypopharynx and cervical esophagus,
C: Cancer of upper thoracic, middle thoracic and lower thoracic esophagus,
$\bar{X}$: Mean value, SD: Standard deviation, SE: Standard error, n: Number of patients,
VC: Vital capacity, FEV: Forced expiratory volume

3) The relation between the pulmonary complications and location of the lesion.

As shown in Table 7, postoperative pulmonary complications occurred in 32 cases (23.7%), of which 11 cases (8.1%) died of this complication. Among 62 patients who had undergone resection of the upper two-thirds of the thoracic esophagus, pulmonary complications occurred in 23 cases (37.0%).

4) Comparison of laboratory and clinical data between the cases of "operative or hospital death" due to pulmonary complications and the cases discharged without any complications.

We investigated the distribution of age, pulmonary function and serum total protein in the preoperative period, the duration of the operation and blood loss during the operation, postoperative blood loss, and postoperative blood gas analysis, that is, minimum P_aO_2 values from the 3rd to the 5th postoperative day in the following 3 groups: eleven cases of "operative death", 8 cases of "hospital death" due to postoperative pulmonary complications

Table 7. Relation between pulmonary complications and location of the lesion

	Resected cases	Pulmonary complications	"Operative death"
Ce	16	2	(2)
Iu	4	2	(1)
Im	58	21	(6)
Ei	14	2	(1)
EC	43	5	(1)
Total	135	32	(11)

Ce: Cervical esophagus, Iu: Upper intra-thoracic esophagus,
Im: Middle intra-thoracic esophagus, Ei: Lower intra-thoracic esophagus,
EC: Esophago-cardiac region

and 8 cases that had been discharged without any severe complications.

As shown in Table 8 and Fig. 1, the value of $FEV_{1.0/m^2}$ (mean ± 1 SE) in the "hospital death" and the cases discharged without any complications were 1474.5 ± 139.40ml and 1533.1 ± 151.6ml, respectively. Arterial O_2 tension (P_aO_2) in the "operative death" group was 72.25 ± 7.56mmHg. This value was lower than those in the other two groups.

Table 8. Results of pulmonary function test and blood gas analysis

		Age	%VC	$\%FEV_{1.0}$	VC/m^2	$FEV_{1.0/m^2}$	Duration of operation	Blood loss	ph	$PaCO_2$	PaO_2
			%	%	ml	ml	min.	ml		mmHg	mmHg
A	$\bar{X}$	64.6	92.1	81.8	1943.9	1533.1	351.9	1594.3	7.441	42.3	96.5
	s	8.53	28.08	9.06	554.6	428.6	39.8	698.7	0.037	5.23	45.08
	SE	3.02	9.93	3.40	196.1	151.6	14.1	247.1	0.013	1.84	15.24
	n	8	8	8	8	8	8	8	8	8	8
B	$\bar{X}$	60.3	95.0	73.6	2041.4	1474.5	333.8	3126.1	7.439	39.0	121.3
	s	7.92	22.89	9.71	577.09	394.22	79.68	2545.2	0.046	7.31	53.18
	SE	2.80	8.09	3.43	204.06	139.40	28.17	900.0	0.016	2.58	18.80
	n	8	8	8	8	8	8	8	8	8	8
C	$\bar{X}$	62.3	93.1	71.0	1898.4	1240.1	280.0	1752.5	7.475	34.4	72.25
	s	8.66	14.64	9.26	339.41	249.29	97.26	1866.81	0.069	7.64	21.38
	SE	2.61	4.63	2.93	107.34	83.09	29.33	562.97	0.024	2.71	7.56
	n	11	10	10	10	9	11	11	8	8	8
A-B	t	1.04	0.23	1.70	0.34	0.28	0.78	1.64	0.10	1.04	1.18
	p	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
A-C	t	0.58	0.10	2.42	0.21	1.17	2.08	0.23	1.34	2.41	1.44
	p	NS	NS	<0.05	NS	NS	<0.05	NS	NS	<0.05	<0.02
B-C	t	0.51	0.21	0.58	0.66	0.90	1.26	1.36	1.33	0.09	2.79
	p	NS	NS	NS	NS	NS	NS	NS	NS	NS	<0.05

A: Discharged cases, B: Cases of "hospital death" C: Cases of "operative death",
VC: Vital capacity, FEV: Forced expiratory volume, NS: Not significant

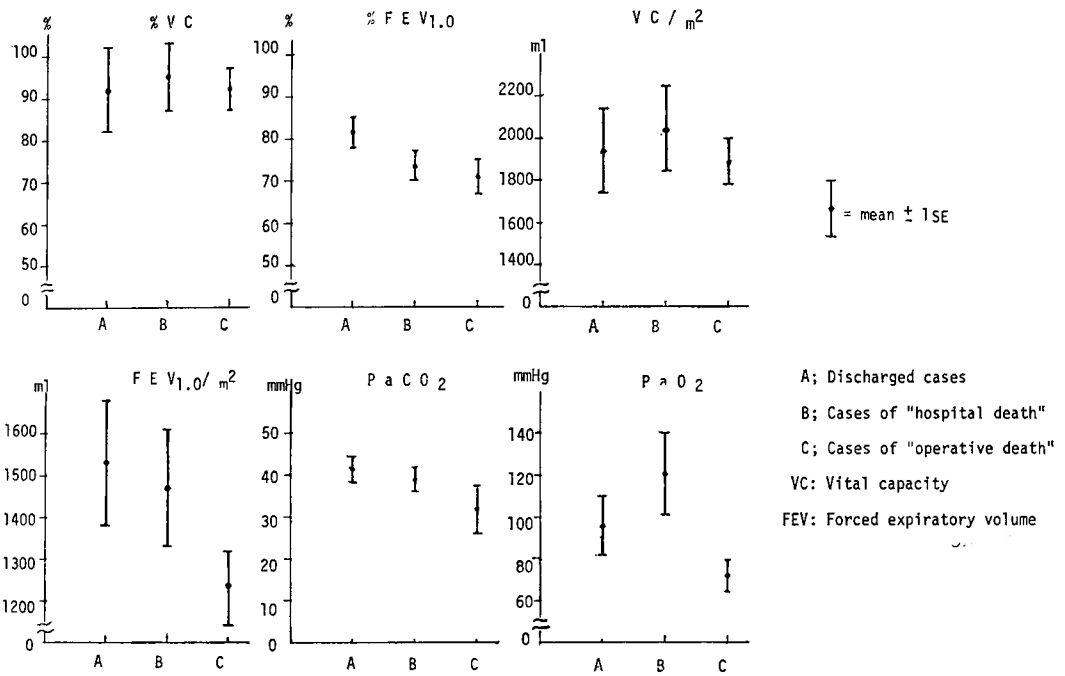

Fig. 1. Preoperative pulmonary functions and postoperative blood gas analysis.

Table 9. Etiologic factors of postoperative pulmonary complications in patients with cancer of the upper two-thirds of the thoracic esophagus.

		Operative death 7	Hospital death 12	Cases of discharge 4	Total 23
Pulmonary complications	Pulmonary edema	2	0	0	2
	Pneumonia	4	9	1	14
	Atelectasis	1	3	3	7
Preoperative pulmonary functions	% VC 80% ↓	1	4	1	6
	% $FEV_{1\cdot0}$ 70% ↓	4	1	1	6
	Normal	2	4	2	8
	$FEV_{1\cdot0/m^2}$ 1400ml	6	5	2	13
Horizontal location and invasion to the adventitia	Circulatory and	5	2	2	9
	anterior wall	1	5 (unknown 4)	2	8
	Definite invasion	4	6	1	11
	Neighboring structures	3	2	0	5
Extent of cleansing of the regional lymphnodes	Cleansing of lymphnodes No. 105 106, 107 & 109	All cases	All cases	All cases	
	Lymphnodes metastases	5	6	0	11

VC: Vital capacity, FEV: Forced expiratory volume,
NO, 105: Upper thoracic paraesophageal lymph nodes,
106: Thoracic paratracheal lymph nodes,
107: Bifurcation lymph nodes, 109: pulmonary hilar lymph nodes

5) The factors of postoperative pulmonary complications in the patients with cancer of the upper two-thirds of the thoracic esophagus.

We investigated the factors of pulmonary complications in the patients who suffered from some postoperative pulmonary complications, such as the laboratory data in pulmonary functions, the location of the lesion, the depth of invasion, the extent of cleansing of the regional lymphnodes (as shown in Table 9) in 7 cases of "operative death" and 12 cases of "hospital death". Four out of the six cases with the cancer of the mid-thoracic esophagus showed the obstructive impairment in pulmonary function test and their values of $FEV_{1.0/m^2}$ were less than 1400 ml.

The main lesions were located in the anterior wall of the esophagus near the bifurcation, invading the adventitia definitely or the neighboring structures in five out of the six cases. In all of these cases, the upper mediastinal and the epibronchial lymphnodes were cleansed and metastases were found in nearly half of them.

Table 10 shows the results of detailed investigations in 6 cases of cancer of the upper two-thirds of the thoracic esophagus out of 11 cases of the "operative death" caused by pulmonary complication.

These findings suggest that injury of the vagus nerves and interruption of the pulmonary lymph flow play an important role in the occurrence of the postoperative pulmonary complications. In addition, most of the patients who had the obstructive impairment of the lung as usually seen in the aged, and who had low $FEV_{1.0/m^2}$ (less than 1400ml) suffered from

Table 10. Operative death due to pulmonary complications

No.	Cases Age Sex	Location of lesion	%VC %	%FEV1.0 %	Type	VC/m^2 ml	$FEV_{1.0/m^2}$ ml	Horizontal location	Invasion to adventitia	Lymphnode	Stage	Pulmonary complication
1.	68 Male	Im.Iu	79	79	Restr.	2083	1386	Total	a_2	107(+)	III	Atelectasis
2.	68 Male	Im.Ei	98	77	Norm.	2099	1591	Post.	a_2	107(−) 109(−)	III	Pneumonia
3.	65 Female	Im	101	54	Obstr.	1996	1039	Total	a_2	107(+)	III	Pulmonary edema
4.	67 Female	Im	91	66	Obstr.	1788	1179	Total	a_2	105(+) 107(−)	III	Pneumonia
5.	67 Male	Im.Ei	94	64	Obstr.	2206	1379	Ante.	a_3	107(+)	IV	Pneumonia
6.	53 Female	Iu.Im	82	66	Obstr.	1303	868	Total	a_3	105(+)	IV	Pneumonia
7.	65 Male	Im	111	71	Norm.	1807	1195	Total	a_3	105(+)	IV	Pulmonary edema

Iu: Cancer of upper intra-thoracic esophagus, Im: Cancer of middle intra-thoracic esophagus,
Ei: Cancer of lower intra-thoracic esophagus, VC: Vital capacity, FEV: Forced expiratory volume,
105: Upper thoracic paraesophageal lymph nodes, 107: Bifurcation lymph nodes, 109: Pulmonary hilar lymph nodes

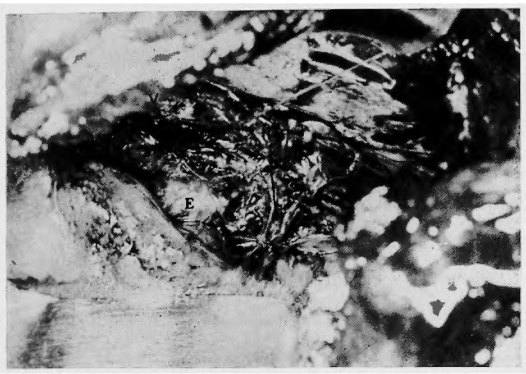

Fig. 2. Vagus nerve and posterior pulmonary plexus are stained with neurostain. (prior to resection of esophagus)

Fig. 3. These nerves are well preserved after resection of esophagus.
E: Esophagus, V: Vagus nerve,
P: Posterior pulmonary plexus

severe pulmonary complications in the postoperative period.

Discussion

Most patients with esophageal cancer are relatively old and have difficulty in swallowing. Therefore, their nutritions tend to be insufficient before the operation and many of them have some cardiopulmonary dysfunctions. The operation for esophageal cancer needs extensive operative invasion (thoracotomy and laparotomy).

A longer duration of operation and more blood loss than other operations of digestive organs are necessary. So, various kinds of serious postoperative complications may occur. The most important complications are the postoperative pulmonary complications, especially pulmonary edema, which has influence on the prognosis of the operation for esophageal cancer.

Many authors[1)2)3)4)] investigated the postoperative complications after surgery for esophageal cancer.

The results of our investigations showed that the main cause of "operative and hospital deaths" was the pulmonary complications. We did not find out the difference of duration of operation and quantity of blood loss between the cases with and without pulmonary complications. Many patients who had the obstructive impairment and marked decrease of $FEV_{1.0/m^2}$ died within a month after operation. The important means to find out the pulmonary complications are the clinical and laboratory examinations, that is, chest X-ray film, physical findings and blood gas analysis, especially the existence of hypoxemia. The relationship between hypoxia and the pulmonary complications have been discussed previously from various points of view[5)6)7)8)9)10)11)12)]. There have been some reports saying that hypoxia occurred at a high frequency in patients who had undergone thoracotomy or even laparotomy. Recently "shock lung" which is found in the patients who had had traumatic injury, burns, sepsis or shock and died of progressive pulmonary insufficiency after temporarily surviving:

ARDS (adult respiratory distress syndrome) and posttraumatic pulmonary insufficiency have been noticed and discussed from various points of view.

The following factors are well known as the cause of hypoxia after operation; 1) ventilatory insufficiency, 2) respiratory or diffusion insufficiency, 3) increase in true shunt due to pulmonary atelectasis, 4) increase in shunt-like effect due to uneven V_A/Q_C ratio, and 5) decrease[22] in cardiac output, etc. (V_A/; Alveolar ventilation/min. Q_C; blood flow through pulmonary capillaries/min.).

Especially, unbalance of V_A/Q_C ratio and increase in anatomical shunt are noticed. With regard to the postoperative hypoxemia, GORDH[7] first reported and then NUNN[8][17] & PAYNE confirmed that the abnormality of V_A/Q_C ratio was the most important factor as the cause of hypoxia from their results of examinations.

Arterial O_2 tension (P_aO_2) in blood gas analysis was less than the normal level within 24 hours after the operation and the ratio of shunt was 25 percent when the patient breathed room air, but it decreased to 12.8 percent when pure oxygen was used. On the other hand, HAMILTON[12] and other authors[19][20] stated that the occurrence of miliary atelectasis caused hypoxia, that the atelectasis was not caused by occlusion of air passage, and that it was improved by deep sighing and breathing.

ROBB[18] described that microemboli prevent blood from flowing in an unobstructed manner through the lung. Pulmonary resistance increases, venous pressures rise, and arterial pressures drop.

The atelectasis which occurred during and after the operative period was not massive but occurred diffusely as miliary atelectasis. The miliary atelectasis was hardly recognizable by chest X-ray film.

Therefore, the result of blood gas analysis could not be improved, even if mucous plug was removed from the air passage. They also said that typical atelectasis occurred accompanied with a decrease of total lung capacity and of pulmonary compliance and increase of venous admixture, and even when P_aO_2 was kept within normal level, because of the number of sedative, spontaneous pain and mechanical restriction of breathing exercise, and persistent constant ventilation.

Therefore, we used a respirator during 12 to 36 hours and sometimes put in force intermittent positive pressure ventilation during this period. DIAMENT[10][11] indicated that the cause of postoperative hypoxia was the increase in true shunt rather than the unbalance of V_A/Q_C ratio judging from the ratio of shunt in pre- and postoperative period.

On the other hand, KELMAN[21] and PHILBIN[22] described that cardiac output or change of oxygen consumption influenced hypoxia.

According to our P_aO_2 value in the patients who died of pulmonary complications within a month after the operation it decreased much more than that in the patients who were discharged without any complications.

Moreover, we investigated the relationship between the pulmonary complications and the operative findings, such as the location of the lesion, the depth of invasion, the extent

of cleansing of the regional lymphnodes in these cases. In the majority of cases the main lesions were located in the anterior wall of the esophagus near bifurcation of the trachea and they definitely invaded the adventitia or the neighboring structures.

The upper mediastinal and the epibronchial lymphnodes were cleansed in all of these cases. Metastases were found in nearly half of them. These findings show that injury of the vagus nerves and the interruption of the pulmonary lymph flow play an important role in the occurrence of postoperative pulmonary complications.

Some authors[23)24)25)] have reported about the relationship between the vagus nerve and the pulmonary complications, especially pulmonary edema. As the cause of pulmonary edema[26)27)], we generally know the followings: 1) increase in hydrostatic pressure of lung, 2) decrease in plasma osmotic pressure[28)], 3) disturbance of pulmonary lymph flow, 4) increase in permeability of pulmonary capillary, and so on.

The acute pulmonary edema after the operation of esophageal cancer, especially in the upper two-thirds of the thoracic esophagus, was caused by injury of the vagus nerve, interruption of the pulmonary lymph flow and hypoproteinemia or malnutrition before operation.

Once the pulmonary edema occurs, it becomes gradually worse because the pure oxygen does not improve the postoperative hypoxia in the presence of considerable pulmonary A-V shunt, and then inspiratory difficulty in breathing may occur due to a decrease of pulmonary compliance. KIMURA[29)] described that the constriction of the smooth muscle due to the interruption of the vagus nerve produced the inspiratory difficulty.

Furthermore, the increase of intrathoracic negative pressure and congestion of vascular bed of the lung are the main causes of pulmonary edema. Therefore, it is important to avoid injury of the vagus nerve as much as possible, especially in cases having lesions in the upper two-thirds of the thoracic esophagus and undergoing cleansing of the lymphnodes.

Thorefore, when we performed resection of the lesion and cleansing of lymphnodes in these portions, we attempted to avoid injury of the posterior pulmonary plexus and vagus nerves by visualizing these structures with neurostain dyeing[30)] Fig. 2 shows that the nerves are stained with neurostain prior to resection of the tumor. Fig. 3 shows that the nerves are well preserved after resection of the tumor and cleansing of the regional lymphnodes.

Conclusion

Among 157 patients of esophageal cancer who were operated in our clinic, the causes of "operative death" and "hospital death" were investigated. The relationship between the operative findings, such as the location of the lesion, the depth of invasion, the extent of cleansing of the regional lymphnodes and the occurrence of postoperative pulmonary complications were also investigated.

1) Among 135 resected cases, there were 99 males and 36 females. Ages ranged from 43 to 80 years, 4 patients (3.0%) were less than 40 years old and 78 patients (57.8%) were over 60 years of age.

2) "The operative death" was seen in 28 cases (17.8%). Among them postoperative pulmonary complications occurred in 11 cases (39.3%) and anastomotic breakdown in 5 cases (17.9%). Among 36 cases of "hospital death", postoperative pulmonary complications were detected in 12 cases (33.3%) and anastomotic breakdown in 7 cases (19.4%). Pulmonary complications occurred in 32 cases (23.7%) out of 135 resected cases.

3) The values of arterial O_2 tension (P_aO_2) in the cases of "operative death" were lower than those of two other groups and the values of $FEV_{1.0/m}$ of this group were less than 1400 ml.

4) Among 32 cases of pulmonary complications, cancer lesion located in the upper two-thirds of the thoracic esophagus in 23 cases and this shows a high incidence as compared with the cases with the lesions in other portions.

5) Most of the main lesions located in the anterior wall of the esophagus near bifurcation and they definitely invaded the adventitia or the neighboring structures in all cases of "the operative death", the upper mediastinal and epibronchal lymphnodes were cleansed and metastases were found in nearly half of them.

The above-mentioned results show that injury of the vagus nerves and the interruption of the pulmonary lymph flow play an important role in the occurrence of postoperative pulmonary complications.

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和文抄録

食道癌術後肺合併症の検討：とくに迷走神経と肺合併症との関連 第1編 臨床的検討

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食道癌手術症例157例を対象として，術後合併症を検討し，さらに直接死亡例および近接死亡例の原因およびこれらの肺合併症と耐術例との肺機能検査成績，手術時間，術中出血量，血液ガス組成の変動などについて比較検討した．

さらに肺合併症が原因で死亡した直接死亡例，近接死亡例およびなんらかの肺合併症をきたした耐術例のうち，上・中胸部食道癌の術前肺機能検査および腫瘤の壁在性，リンパ節郭清の程度，リンパ節転移の状態について検討した．

1) 切除数135例のうち男性は99例，女性は36例であり，40才以下は4例，3.0%にすぎず，60才以上が78例，57.8%を占め高令者が多かった．

2) 直接死亡例は28例，17.8%であり，原因別では肺合併症11例，39.3%，縫合不全5例，17.9%などが多かった．近接死亡例は36例，22.9%であり，肺合併症12例，33.3%，縫合不全7例，19.4%などが多かった．また全症例のうち肺合併症例は32例，38.6%であり，切除数の23.7%に相当した．

3) 直接死亡例，近接死亡例および耐術例を比較すると，術前肺機能検査成績中の $FEV_{1.0/m^2}$ および術後の血液ガス PaO_2 が直接死亡群において他の2群に比して低値を示した．

4) 肺合併症総数32例のうち，占居部位別にみると，上・中胸部食道癌例が23例であり，上・中胸部切除数62例の37.1%を占め，他の部位より高率であった．

5) 肺合併症が原因となった直接死亡例の病巣占居部位は上・中胸部例が63.6%と高率であった．これら肺合併症例において，主癌病巣が上・中胸部食道，とくに気管分岐部近くの前壁を中心に局在しており，外膜浸潤も a_2～a_3 症例で，全例に105，106，107，109のリンパ節の郭清が行われており，その半数以上にリンパ節転移を認めた．

これらの成績から術後肺合併症が上・中胸部食道癌手術に多く，さらに腫瘤が気管分岐部周辺に存在し，外膜浸潤のあるものほど多かったことから，病巣摘出およびリンパ節郭清のさいの迷走神経損傷および肺リンパの還流遮断などが，食道癌術後肺合併症の発生に関与していることを指摘した．

このような術後肺合併症予防対策として，われわれはこれらの手術操作のさいに Neurostain 染色を応用して，なるべく迷走神経細枝や後肺神経叢の損傷をさけるべく努力しており，これによって術後肺合併症の予防のうえに良好な成績をえている．